# THESIS

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# Investigation of the situation and development potential of the Mexican sugarcane industry

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# **Table of contents**

Introduction	
1LITERATURE REVIEW	7
1.1.1 Origin of sugarcane	7
1.1.2 Uses of sugarcane	7
1.1.3 Morphology of sugarcane	7
1.1.4 Growth stages of sugarcane	
1.1.5 Soil conditions of sugarcane	
1.1.6 Climatic conditions	8
1.1.7 Crop rotation	9
1.1.8 Nutrient supply	9
1.1.9 Planting data of sugarcane	9
1.1. Competitiveness of agriculture in Mexico	10
1.3 Agriculture in Mexico	14
1.4 World sugar market and prospects	16
1.5. Mexico sugar industry	19
1.5.1. History of the sugar industry of Mexico	
1.5.2. The national economic importance of the sugar industry to Mexico	20
1.6. Agricultural policy of Mexico	20
1.6.1 Market regulation	23
1.6.2. Sugarcane support programs in Mexico	24
1.7. Defining rural development and its importance in Mexico	25
1.7.1 Rural area	25
1.7.2 Urban area	26
1.7.3 Rural development and roles in Mexico	27
2. MATERIAL AND METHOD	30
2.1.1 Presentation of the study area	30
2.1.2. Industry	<u>31</u>
2.1.3. Tourism	31
2.1.4. Climate	31
2.1.5. Transport	31

2.2. Secondary research	32
2.3. Primary research	32
3. RESULT AND THEIR EVALUATION	34
3.1. The situation of sugar cane in Veracruz	34
3.1.2. Indicators in Veracruz 2019.	35
3.1.3. Type of sugar produced in Veracruz	35
3.1.4. Key companies in the food value chain in Veracruz	35
3.1.5 Varieties	35
3.2 The results of the in-depth interview	40
4. CONCLUSIONS AND RECOMMENDATIONS	46
5. SUMMARY	48
6. BIBLIOGRAPHY	52
7. LIST OF TABLES AND FIGURES	54

#### Introduction

The present work is an investigation of the situation and development potential of the Mexican sugar cane industry, which aims to examine the current situation and the characteristics of the Mexican sugar cane sector in terms of cultivation, harvest and extraction process and obtaining of by-products; this sector is highly relevant because sugar cane is the sixth most important crop in Mexico. There are 32 states that make up Mexico, in 15 of them this crop is grown because it is attractive due to its productive diversity and is a necessary source of direct and indirect jobs in fields and factories.

The objective is to investigate the level of competitiveness of the Mexican sugar cane sector, because currently producers face a crucial competitive crisis, the causes have been several, including drought, low production in some states at the country level and quality of cane, sugar mills with technology obsolete or null, high production costs and direct and indirect competition in the market due to the importation of natural and artificial sweeteners.

The goal is achieving a positive impact in the rural environment, because the sugar cane producers live in the Sierra (small towns), far from the roads, they are indigenous people, their main source of economic income is sales from piloncillo or panela and by-products, which are obtained from sugar cane, nowadays, in most sugar mills and mills, the juice extraction process is 100% natural, and is carried out manually or traditional, no refining process is used, horses or donkeys are used whose function is to pull a log of wood that is attached to a mill that squeezes the cane, and when the brown sugar is crystallized, it is wrapped in the leaf of the sugarcane and is sold in local markets, for this reason it is necessary to pay attention to this vulnerable population that has many areas of opportunity and thus propose alternatives for improvement in the extraction process to facilitate the activity to the producers.

Defining development opportunities is also required because the Mexican sugar industry is not competitive at the national level due to the high production costs in cultivation, harvesting and transportation and the lack of technology, that is, infrastructure in the field and in the factories have not improved and the marketing of sugar cane depends on the domestic market, however, there are great development opportunities for the Mexican sugar industry, because it has extensive cultivation areas, there is assured and growing internal demand because it is a traditional and frequently consumed product, there is availability of labour, that is, the generation of direct and indirect jobs in the field and industry.

The Mexican sugar activity, as an agro-industrial system, is made up of two elements, the field and the industry, in each one there are sugarcane producers and industrialists who have different elements for production, in the agricultural aspect, there are plantations in which they are implanted modern techniques that increase production, but there are also smaller-scale producers whose yield is lower and have high production costs, this situation also occurs in the sugar mills, in addition to the fact that the two subsectors are affected by the high costs of transport the product from the fields to the mills.

This work will contribute significantly mainly to producers through the search for development strategies that increase the competitiveness, efficiency, and profitability of this sector by suggesting the adoption of new sugar extraction technologies, diversification of products and by-products, and aggregation of value with commercial potential, for the benefit of all stakeholders.

#### **1.-LITERATURE REVIEW**

#### 1.1.1. Origin of sugarcane

Sugarcane species are originated from tropical South and Southeast Asia. It is probably domesticated in New Guinea around 6,000 B.C. first. There are evidences that it was produced in India around 1,000 B.C. (Péter, 2013).

In the VIIIth century the Arabs introduced it into the Mediterranean, North Africa and Mesopotamia. It reached America around 1,500 A.D. from the Canary Islands. Now sugarcane is a major export crop for many tropical countries. (Péter, 2013).

#### 1.1.2. Uses of sugarcane

- The main purpose of sugarcane growing is to produce sugar. Sugar is usable directly for human consumption and food industry, or it may be used in further processing.
- The cane-sugar is used to produce ethanol for utilizing in many ways: biofuel (bioethanol) an alternative to gasoline, industrial alcohol, alcoholic beverages, etc.
- It can be used in fibre, paper, and cardboard production.
- Mixed with other ingredients sugarcane bagasse can be used as organic fertilizer.
- The by-products of sugar industry, the bagasse and molasses.
- Leftover sugarcane biomass can be burned and converted into electricity.
- Molasses can be fermented to make rum. Sugarcane was first used to make rum in the West Indies.
- Sugarcane can be used to produce bioplastics, beverage bottles, food containers, packaging, etc. (Péter, 2013).

# 1.1.3. Morphology of sugarcane

Roots: Sugarcane is vegetatively propagated. As it belongs to the Grass family (Poaceae) it has a fibrous root system. It has sett roots and shoot roots. The roots can penetrate deep in the soil, the rooting zone can be found in the 30- 800 cm layer of the soil. (Péter, 2013).

Stem: It is a herbaceous, perennial grass, belongs to C4 type plants. The talks are 300-400 (600) cm high and up to 5 cm in diameter. The stem covered by wax layer. There are joints consists of one node, one internode. Sugarcane develops 5-50 tillers (secondary shoots). (Péter, 2013).

Leaves: The leaf consists of sheath and blade. The blade is 100-150 cm long and 10 cm wide, gently curved. It is pubescent. (Péter, 2013).

Flower: The inflorescence is a 60 cm long panicle, often called ||arrow||. The spikelets are 3 mm long, bear long silky hairs. The plant is harvested before the inflorescence appears. (Péter, 2013).

Fruit: The fruit is dry caryopsis. There is one grain in a spikelet. 1000 grain mass: 4 g. (Péter, 2013).

#### 1.1.4. Growth stages of sugarcane

- germination and establishment
- tillering
- grand growth period
- ripening, (Péter, 2013).

#### 1.1.5. Soil conditions of sugarcane

Best soils for sugarcane production are the fertile, deep layer soils that are well supplied with minerals and organic matter. Free draining and good nutrient supplying ability are important. The soil could be light (but not sandy) or heavy. (Péter, 2013).

# 1.1.6. Climatic conditions

Due to its tropical origin, sugarcane prefers warm, wet climate. The optimum temperature is 32-38°C. The main temperature should not fall below 21 °C. Light freezes (-3°C) kill the leaf tissue and stop sugar accumulation. Sugarcane requires minimum 1500 mm rain in the

growing season. Short dry period before harvesting supports sucrose accumulation. It is a short-day plant. (Péter, 2013).

#### 1.1.7. Crop rotation

Most sugarcane in the world is grown in monocropping system. It is grown for 2 to 5 years continuously, and then new crop of sugarcane is planted. Fallow should be left for 6-12 month before replanting sugarcane. (Péter, 2013).

#### 1.1.8. Nutrient supply

Recommended fertilizer doses N: 40 – 220 (kg/ha) P2O5: 125 – 500 (kg/ha) K2O: 60 – 375 (kg/ha)

N-fixation: Glucoacetobacter diazotrophicus bacteria live in the intercellular spaces of the stem of sugarcane. These bacteria can fix aerial nitrogen and convert it into nitrites or nitrates, similar as the Rhizobium bacteria do living on the roots of legumes. (Péter, 2013).

# 1.1.9. Planting data of sugarcane

Planting date: Grown under diverse agro-climatic conditions in the world, therefore there is variation in the optimum planting periods in different countries.

Row spacing: 150-180 cm

Plant spacing: 60 cm

Depth: 2.5-5 cm (from the original soil surface)

Planting rate: 12 500 - 20 000 setts/ha. (Péter, 2013).

#### 1.2. Competitiveness of agriculture in Mexico

Sugarcane production in Mexico has more than 490 years of history; however, Mexican sugar industry is recognized as uncompetitive in nature, mainly due to stagnating low sugarcane and sucrose yield and highly fiber in stalks per hectare and variability in the production process. (Aguilar, 2012).

The sugar mills are characterized by a dichotomy because vary greatly in size, age and technology with a preponderance of medium and small mills, old, obsolete and inefficient technologies, which increases the cost of sugar production in Mexico compared to countries with advanced technology and supporting system. Therefore, Mexico is considered as a medium-to-low-cost producer of sugar. These factors have adversely affected sugarcane growers and sugar industry, and constantly eroding their sustainability and profitability. (Aguilar, 2012).

Globally, because of its impact on employment and income in rural areas where it is usually established, the sugar industry is a highly protected activity in virtually all producing countries. In Mexico, this has resulted in the survival of sugar mills and cane fields with high operating costs and low levels of competitiveness, few, or no incentives to retrain, and, in addition, a pattern of land ownership that creates fragmentation and low productivity in the field and high cultivation costs. This situation leads to the disintegration of production processes in sugarcane fields, the sugar industry, marketing, and direct and indirect consumption. (Carrillo, 2021).

Cane cutting is a difficult job, as workers must labour in high temperatures. As a result, the sector is finding fewer and fewer workers each year, as workers prefer to work on less intensive crops. The continued loss of labour in the sugar cane sector will be detrimental due to the lack of harvest mechanization available in the country. (Osoyo, 2020).

Sugarcane (Saccharum spp.) is a globally important crop since it provides nearly 80% of the sugar consumed worldwide. Nevertheless, sustainability and social responsibility are still unmet goals in most sugarcane production systems worldwide, including in Mexico, which is the sixth largest producer of sugar and sugarcane. Mexico's production has not been focused on exportation, but rather on domestic consumption. (Herrera, 2017).

According to FAO (Food and Agriculture Organization), sugarcane production in Mexico was 59334059 tons in 2019, as shown in the Figure 1, which represents 4% of world production, this places Mexico as the sixth producer of sugarcane.



Figure 1 Global sugarcane production in 2019 (Source: FAO, 2019.)

In Mexico, at the country level, as can be shown in Figure 2, the harvested area of sugar cane is 795984 hectares in 2019, which represents 4% which shows competitiveness and places the country among the main supplier countries.



Figure 1 Global harvested area in 2019 (Source: FAO, 2019.)

The Figure 3 represents the harvested area from 2010 to 2020, it is analysed that the year with the best sugarcane harvests has been 2019.



Figure 3 Harvested area between 2010 and 2020 (Source: FAOSTAT, 2022.)

The factors involved in the decrease in yield are due to the migration of farmers, climate change, lack of government support, and low utility in sales and market prices (Figure 4).



Figure 4 Annual yield of sugarcane between 2010 and 2020 (Source: FAOSTAT, 2022.)

In 2020, the value of the total production at the country level was 53952698 tons, a decrease compared to the previous year (Figure 5).



Figure 5 Production quantity between 2010 and 2020

(Source: FAOSTAT, 2022.)

The Mexican sugarcane production system, as raw material, is embedded in a mosaic of cultural, social, political, economic, technical, and educational factors that limit industrial production. To solve this problem, it is necessary to begin with the primary sector: Agriculture. The agrarian structure in Mexico in general, and sugarcane crops, is characterized by its high fragmentation, it means the high prevalence of production units of small size: Farm fragmentation has been identified as a major barrier to productivity. (Rivera, 2018).

#### **1.3 Agriculture in Mexico**

Since the 13th century, indigenous inhabitants of Mexico have been developing innovative ways of ensuring their livelihoods via agriculture by building 'floating lands' on which they grew crops. Today, Mexico covers a territory of 198 million hectares, of which 15% is devoted to agricultural crops and 58% is used for livestock farming. The most profitable agricultural products of Mexico are coffee, sugarcane, and cotton. Additionally, the top production is avocado. Mexico has a competitive advantage because of its available fertile land mainly in the centre and south part (Figure 6), where the possibility of cultivation of diverse types of crops on a large scale exists. (Maastricht, 2021).

Mexico produces large quantities of maize (corn), coffee, sugar cane, beans tomatoes and avocados. Mexico also produces tropical products such as sugarcane, bananas, pineapples, papayas, mangoes, coffee, and cacao. Rice, cotton, wheat, peanuts and strawberries are also grown, and Mexico is a leading world producer of vanilla, used for food flavouring. (Kingdom, 2021).



Figure 6 Land suitability for rainfed sugarcane crop in Mexico, 2018.

(Source: Rivera, 2018.)

In Mexico, a third of the agricultural land 32.25% presents a high and medium level of suitability for the cultivation of sugarcane and 67.75% are no suitable; but these areas can currently have different land uses, therefore, it is a priority to use sustainable technology for the management of the current sugarcane regions, without considering future expansion for growing cane in jungles, forests or grasslands producers of food, feed, timber resources or environmental services. (Cuello, 2018).



Figure 7 Agricultural land in Mexico, 2018.

(Source: World-Bank, 2022)

The figure 7 shows that the agricultural land (% of land area) in Mexico was reported at 54.99 % in 2018, according to the World Bank collection of development indicators, compiled from officially recognized sources. Mexico, Agricultural land (% of land area) - actual values, historical data, forecasts and projections were sourced from the World Bank in April of 2022. Agricultural land refers to the share of land area that is arable, under permanent crops, and under permanent pastures. Arable land includes land defined by the FAO as land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow. (Bank, 2022).

#### 1.4 World sugar market and prospects

The figure 8 shows the principal sugar exporting countries in 2020/2021, Mexico is the world's 6th largest exporter of sugarcane, and the main supplier of sugar to the USA. For the 2010-2011 season, sugar exports to the USA totalled a record 1.3 million metric tons.

This sector has been increasing rapidly in recent years, partly due to sugarcane's inclusion under the terms of NAFTA. Despite its exports, Mexico also imports small quantities of sugar, mainly from Nicaragua to maintain its own sugar reserves of around 1 million tons. (Burton, 2021).



Figure 8 Export in million metric tons

(Source: FAO, 2020.)

World sugar production will experience a surplus during 2021-2022, 5.18 million tons of sugar will be produced more than in the previous period, this would represent an increase of 5%. A global surplus of 5.18 million tonnes is projected, generated in part by higher production of the sweetener in Thailand and India, compared to the deficit of 2.01 million tonnes in 2020-2021, on a comparative basis from October to September. World sugar consumption is expected to increase by 1% in 2021-2022, to 186.33 million tons. (Aguirre, 2021).

Sugarcane demand will grow for food and fuel production, driven by increased sugar consumption in Asia and Africa. 75% of the sugarcane produced globally is consumed by the food manufacturing sector; the balance is used in biofuel production. (Baliño, 2019).

Figure 9 shows the major cane sugar-consuming companies and their sustainable sourcing commitments. In Mexico there are 6 companies that buy sugar and sugar by-products to produce beverages and foodstuffs, which is a positive scenario that has scope for large-scale sales in the future. (Aguirre, 2021).



Figure 9 Consumption in metric tonnes by the major companies (Source: Aguirre 2020.)

Incentivizing consumers to purchase more compliant sugarcane in the largest producing countries is an important opportunity, particularly if prices become more competitive with conventional sugarcane. (Voora, 2020).

Sugar consumption has declined in recent years because of several changes, such as in domestic and international prices, the supply and demand of sugar, people's consumption habits, the food industry's demand and the presence of substitute products and non-caloric sweeteners. (Carrillo, 2021).

#### 1.5. Mexico sugar industry

#### 1.5.1. History of the sugar industry of Mexico

Sugarcane (Saccharum Officinarum), belonging to the grass family, originated from Asia where its cultivation began around the year 327 BC, and whose production spread to Europe in the fourth century of that era. To the American continent, sugar cane arrived with the Spanish colonizers, being Santo Domingo the first country where it was cultivated on a large scale and expanding to Cuba, Mexico and other countries in South America and the Caribbean. The figure 10 shows that at the end of the 80s, more than 90 countries were sugar producers, so Mexico has more than 15 states that produce sugar cane, which is processed in approximately 60 mills, distributed in the cane-producing areas. After the second decade of the last century and until 1980, in Mexico the sugar mills were managed by the State, so this industry was highly subsidized and the policy was erratic regarding the production of sugar cane. (Espinoza, 2005).



Figure 10 Sugarcane in America (Source: Espinoza, 1885.)

#### 1.5.2. The national economic importance of the sugar industry to Mexico

Sugarcane industries provide significant full and part time employment for more than 450,000 jobs, including cane cutters, seasonal field workers, cane transport, factory workers and administrative, technical and management personnel. Consequently, over 2.2 million people depend on the Mexican sugar industry for a direct job and indirectly employing more than 12 million people in 227 municipalities most of them are the rural communities. (Osoyo, 2020).

Sugar production is carried out in 57 sugar mills spread throughout the country and has made it possible for 664,000 hectares of sugarcane to be industrialized. Production has reached nearly 5 million tons of sugar with a value close to 27 billion pesos, contributing 11.6% of the GDP in the primary sector and 2.5% of manufacturing GDP. (Carrillo, 2021).

The uses of sugar cane are diverse: animal fodder, ethanol, refined sugar, brown sugar, white sugar, refreshment industry, pulp and paper, cake shop, pharmaceutical sector, fuel, and export. The sugar industry forms an integral part of the rural economy and provides high incomes for its farmers or canegrowers, most of the sugar produced in Mexico is consumed domestically, even is considered as basic product which indicate the economic importance of sugar in the national diet. (Rodríguez, 2020).

#### 1.6. Agricultural policy of Mexico

The following is a description of the most important stages that relate to the agricultural policy of the sugar sector and the changes that have taken place over time:

- (1980): The sugar mills were administered and managed by the Mexican government, so the sugar cane industry was highly subsidized. (Espinoza, 2019).
- (1988-1990): The Mexican sugar agribusiness went through an excess supply in the domestic market for imported volumes, as well as market destabilization, over-indebtedness, and past due portfolio, in the same way, there was limited access to

credit, stagnation in the productivity of sugarcane fields and mills with loss of profitability, which made it difficult to pay debts and caused the definitive closure of several mills. (Espinoza, 2019).

- (1988-1994): In the presidential period of Carlos Salinas de Gortari, it was proposed to sell the sugar mills to private initiative, supposedly due to the urgency of their modernization in the country, for this reason they were sold at extremely low prices to a small group of businessmen, among whom were they found partners of refreshment companies. (Espinoza, 2019).
- (1992): Mexico acceded to NAFTA formed by Canada, the United States and Mexico, which entered into force on January 1, 1994. The country granted tariff-free access to its markets to 36% of agri-food imports from the United States. America and 41% of agri-food imports from Canada. (Espinoza, 2019).
- (1994): all import permits were converted to tariff quotas. In that same year, the NAFTA Free Trade Agreement with North America came into force. This Agreement had a strong impact on the commercial and agricultural policy of Mexico since it promoted trade without modifying the policies of domestic support and export subsidies. (Espinoza, 2019).
- (2001): The President Vicente Fox made the decision to nationalize 27 mills at public expense, supposedly to mitigate the crisis in the sugar industry, but these mills had considerable debts in areas such as tax obligations, social security, credit debts, as well as those that were contracted with producers and day laborers, which amounted to more than 3 billion dollars, which finally had a fiscal cost of more than 19 billion pesos. (Espinoza, 2019).
- (2005): On August 22, 2005, the decree issuing the Law for the Sustainable Development of Sugarcane was published in the Official Gazette of the Federation. The purpose of said law is to consolidate the sugar agroindustry, and regulate the activities associated with contract farming and the sustainable integration of sugarcane, the processes of sowing, cultivation, harvesting, industrialization, and commercialization. of sugar cane, its products, by-products, co-products, and

derivatives, with the intention of turning it into a more competitive strategic activity and so that it has operating capacity in the face of global competition conditions and the deregulatory mechanisms established by Federal Law of Economic Competition. (Espinoza, 2019).

- (2006) since the government of Vicente Fox Quesada, agricultural policy is the responsibility of SAGARPA. The Sectorial Program for Agriculture, Livestock, Rural Development, and Food is put into operation, which sets out as a vision A productive, competitive rural environment committed to conserving and improving the environment based on the comprehensive improvement of the human factor. (Espinoza, 2019).
- (2012): The Sustainable Rural Development Law was published, in article 12, it indicates that the State is responsible for the leadership of national development and the conduct of the sustainable rural development policy, which will be exercised through government agencies and entities federal and through the agreements that it celebrates with the governments of the federative entities, and through them, with the municipal governments according to the provisions of Article 25 of the political constitution of the United Mexican States. The agency government are The Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA) and National Committee for the Sustainable Development of Sugar Cane (CONADESUCA). (Espinoza, 2019).

Agricultural policy is the set of measures and instruments applied by the state in agricultural matters to achieve the socio-economic development of the countryside. This policy can be divided into agricultural, livestock, forestry, and fisheries policy. Each of these policies applies certain measures to promote the activity to which it is directed, in such a way that the set of instruments and measures applied by the agricultural policy contributes to the general economic policy to achieve the socio-economic development of the country. (Río, 2013).

In Mexico, the main institutions in charge of agricultural policy at present are:

- Secretary of Agriculture, Livestock, Rural Development, Fisheries and Food. (SAGARPA).
- Secretary of Agrarian Reform (SRA).
- Secretary of the Environment and Natural Resources (SEMARNAT).
- Rural Financial.
- Trusts Instituted in Relation to Agriculture (FIRA).

# 1.6.1 Market regulation

The Ministry of Economy, through the General Directorate of Light Industries, based on articles 34 sections I and XXXIII of the Organic Law of the Federal Public Administration; 57 of the Law for the Sustainable Development of Sugarcane; 12 section IX and 33 section IX of the Internal Regulations of the Ministry of Economy, and in response to the request received from the General Directorate of the National Committee for the Sustainable Development of Sugarcane, through its office number AFU- DG-0143-2020 dated October 16, 2020, by means of which it sent the document containing the proposal of that Committee regarding the reference price of standard base sugar for the payment of sugarcane for the 2020/2021 harvest for its corresponding publication in the Official Gazette of the Federation within the month of October 2020, discloses the proposal prepared by said Committee, in the following terms (Table 1).

Table 1 Market	regulation	n in Mexico	
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Reference price	The reference price of the standard base sugar for the	
	payment of sugar cane corresponding to the 2020/2021	
	harvest will be \$ 15,049.65 pesos per ton.	
Export	The amount of the maximum quota to export sugar to the	
	United States of America is 841,794,910 metric tons	

(Source: Rodríguez, 2020)

# 1.6.2. Sugarcane support programs in Mexico

Mentioned below are some financing options that are useful and open to agricultural producers (Table 2)

Program	Description	Period to apply
Wellness program	The program integrates its direct support to	March-April
for small or	sugarcane producers, they will receive \$	(every year)
medium scale	7,300 Mexican pesos from 2020 through the	
producer	Secretariat of Agriculture and Rural	
	Development, for producers who have up to	
	20 hectares of rainfed or up to 5 hectares of	
	irrigation	
Program of the	The acquisition of new machinery will be	March-May (every
special support	supported; The federal contribution will be	year)
fund for	up to \$ 20,000.00 Mexican pesos per	
investment in	individual applicant, the support will be	
sugarcane	limited to the acquisition of cane loaders,	
	rotors, cane harvesters or trailers.	
Fundation	Credit for sustainable businesses: This is a	January to
Banamex	loan with a fixed annual rate of 14.25% with	December
	flexible terms of 12 to 48 months, for the	
	acquisition of fixed assets.	
Premio Eugenio	Recognition of civil associations that	January to March
Garza Sada	promote the development and welfare of	2022
	Mexico.	
	Financing amount: \$150,000.00 pesos	
Undersecretary	Program: support for sustainable development	January to August
for Social	projects, collaborative work, creativity, and	2022
Participation and	innovation.	
Craft Promotion.	Financing amount: \$250,000.00 pesos	

Table 2 Support programs

Agriculture promotion program: support for	January to April
supplies, infrastructure, machinery and	every year
equipment, training, social and human	
development.	
\$100,000.00 to \$5,000,000.00	
Self-employment promotion program,	March to June
economic resources are allocated to producers	every year
and micro-enterprises mainly for the purchase	
of machinery and fixed assets, the minimum	
amount to request is \$100,000.00 up to	
\$900,000.00	
	Agriculture promotion program: support for supplies, infrastructure, machinery and equipment, training, social and human development. \$100,000.00 to \$5,000,000.00 Self-employment promotion program, economic resources are allocated to producers and micro-enterprises mainly for the purchase of machinery and fixed assets, the minimum amount to request is \$100,000.00 up to \$900,000.00

(Source: Arroyo, 2020)

# 1.7. Defining rural development and its importance in Mexico

#### 1.7.1 Rural area

A rural area is an open swath of land that has few homes or other buildings, and not very many people. A rural area's population density is very low, defined as those localities with less than 2,500 inhabitants. In a rural area, there are fewer people, and their homes and businesses are located far away from one another. Agriculture is the primary industry in most rural areas. Most people live or work on farms or ranches. Hamlets, villages, towns, and other small settlements are in or surrounded by rural areas. (Rutledge, 2011).

Rural population (% of total population) in Mexico was reported at 19.56 % in 2019 as the Figure 11 shows, but the rural population decreased at 16% in 2021 according to the World Bank collection of development indicators, compiled from officially recognized sources.





# 1.7.2 Urban area

An urban area is the region surrounding a city. Most inhabitants of urban areas have nonagricultural jobs. Urban areas are very developed, meaning there is a density of human structures such as houses, commercial buildings, roads, bridges, and railways. Urban area can refer to towns, cities, and suburbs. An urban area includes the city itself, as well as the surrounding areas. Many urban areas are called metropolitan areas. (Rutledge, 2011).

- The current population of Mexico is 130,223,895 as of Tuesday, June 15, 2021, based on report elaboration of the latest United Nations data.
- The urban area is considered with more than 2500 inhabitants.
- 83.8 % of the population is urban (108,074,410 people in 2020)

The figure 12 shows that Mexico population is equivalent to 1.65% of the total world population according with the World Bank. Rural population refers to people living in rural areas as defined by national statistical offices. It is calculated as the difference between total population and urban population. Aggregation of urban and rural population may not add up to total population because of different country coverages.

Mexico rural population for 2020 was 24,948,670, a 0.42% decline from 2019. Mexico rural population for 2019 was 24,948,670, a 0.37% decline from 2018. Mexico rural population for 2018 was 25,041,299, a 0.32% decline from 2017. Mexico rural population for 2017 was 25,121,419, a 0.27% decline from 2016.



Figure 12 Urban population in Mexico, millions of people.

(Source: World Bank, 2022.)

# 1.7.3 Rural development and roles in Mexico

Rural development generally refers to the process of improving the quality of life and economic well-being of people living in relatively isolated and sparsely populated areas. Rural development has traditionally centred on the exploitation of land-intensive natural resources such as agriculture and agricultural processing, forestry, crops, livestock, and fishing. However, changes in global production networks and increased urbanization have changed the character of rural areas. Education, health, entrepreneurship, physical and rural infrastructure, marketing, roads, transport, energy, water, mining, and social infrastructure all play an important role in developing rural regions. (Stockbridge, 2015).

In table 3 economic data and general data of Mexico are mentioned:

Factor	Description
Poverty	Poverty continues to be more intense in rural areas than in urban
	areas: extreme poverty affects 17.4% of the rural population, while
	in urban areas extreme poverty reaches 4.4%
Agriculture	The primary sector employed around 13.3% of the total employed
	population nationwide. This level exceeds 3.1% of participation of
	the primary sector in the national GDP.
Land tenure	More than half of the ejidatarios, private owners, community
	members and possessors own up to five hectares or less; and more
	than 20% of those land holders have their land divided into three
	or more fractions, many times widely separated from each other.
Agricultural	It is an issue that requires urgent attention. Soil degradation affects
production and	89 million hectares at national level.
environment	
Domestic,	Women in the countryside participate in the development of the
agricultural, and	country: In sum, one million 877,000 women are currently being
artisanal field.	the owners of the land, which are distributed among 701,000
	ejidatarios, 201,000 comuneras, 656,000 landowners and 318,000
	private owners.
Rural youth without	The number of young rural population is high and does not have
access to land	access to land for agricultural use (population from 0 to 14 years
	old in rural localities is 33.2% and in localities with more than
	100,000 inhabitants it reaches 26%).
Indigenous villages	The indigenous represent approximately 10% of the national
	population; They participate in 6,830 ejidos and communities in
	the country that represent 22.9% of the agrarian nucleus.
Agricultural laborers	It is reported that there are 3.9 million agricultural workers in the
	country, 2.5 million of whom are laborers or day laborers in
	agriculture, but currently it is estimated that the population

Table 3 General data of Mexico

	affected by this work activity reaches 5.9 million people. More
	than 90% of Mexican day laborers they do not have social security.
Education of the day	The average schooling of the agricultural labourer population is
labourer population	5.9 years, that is, incomplete primary school and around a quarter
	of that population (24%) does not speak Spanish but an indigenous
	language.
Agricultural laborers	Day laborers earn an average of 18.5 pesos per hour worked, (1
salary	dollar) an amount that, despite exceeding 80.04 pesos a day of the
	minimum wage.
Rural emigration	It is likely that inhabitants of small towns are moving from
	intermediate rural towns to larger towns, which may be due to
	times of greater economic and social uncertainty.
Forest areas	The forest areas that include forests, jungles and bushes cover 70%
	of the national territory. Around 17 million people live in them.
Current use of	The Sustainable Rural Development Law, in its article 179,
agricultural land	considers seven crops as basic and strategic: corn, sugarcane,
	beans, wheat, rice, sorghum and coffee. If we add the most
	important oilseeds (cotton, soybeans, and safflower), the
	commodities and the crops to feed the livestock (oats, fodder corn,
	cultivated pastures), there are 30 products that occupy 87% of the
	arable area.

(Source: Own elaboration with data from FAO,2018.)

#### 2. MATERIAL AND METHOD

#### 2.1.1 Presentation of the study area

The eastern state of Veracruz is famed for its long coastline on the Gulf of Mexico. Bordering the states of Tamaulipas, Oaxaca, San Luis Potosi, Puebla, Chiapas, Hidalgo, and Tabasco, Veracruz is a particularly notable state for many reasons including its landscape, cuisine, history, and cultural appeal. (Lundy, 2021).

The eleventh largest state in Mexico, Veracruz boasts an area of 27,730 square miles. Its population is 7,712,364, making it the third-most populous state in Mexico. Veracruz was granted statehood in 1823. The state is well known for its mixed ethnic population and a considerable population of indigenous groups. The busy port of Veracruz fostered the influx of peoples from abroad, their cultural practices, and their cuisine that all add to the state's melting pot charm. The capital of the state is the city of Xalapa-Enriquez, which is the state's second-most populous city and revered for its parks and culture. (Lundy, 2021).



Figure 13 Location of Veracruz, Mexico (Source: INEGI, 2022.)

#### 2.1.2. Industry

Veracruz is an important oil-producing state for Mexico. It also enjoys a successful textile industry. In terms of agriculture, the state is well known for crops like sugarcane, corn, tobacco, and various citrus fruits. As with many other nearby states, raising livestock is an important endeavour for regional peoples. (Lundy, 2021).

#### 2.1.3. Tourism

The state's tourism industry is primarily based in the city of Veracruz, but the capital is also revered for its cultural attractions. Eco-tourism occurs in the tropical regions as well as the coffee-producing sections of the state. Archaeological sites like the ruins of El Tajin are also popular among visitors to the state. Veracruz is widely revered for its culinary influences and culture, both of which attract tourists to its confines. (Lundy, 2021).

# 2.1.4. Climate

The climates of Veracruz are varied: warm humid, warm subhumid, semi-warm humid, temperate humid, semi cold, and cold. (Lundy, 2021).

#### 2.1.5. Transport

Veracruz has 3 commercial seaports and 5 cabotage seaports; through which 30% of the cargo transported by sea and 30% of the country's national containerized cargo moves. There are 3 strategically located airports in the State, in the north, centre, and south, two of them are for domestic flights and one for international flights. (Lundy, 2021).

#### 2.2. Secondary research

To carry out this research work, documentary research was carried out from information available in different sources such as: Agrifood Information Service and Fisheries of the Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA), National Committee for the Sustainable Development of Sugar Cane (CONADESUCA), National Program for the Sugarcane Agroindustry (PRONAC), National Institute of Statistics and Geography (INEGI), as well as studies carried out by various authors, related to the general problem of sugar agribusiness in Mexico and Veracruz in particular.

This chapter mentions important general data that characterize Veracruz, and specific data related to the production of sugar cane based on interviews with producers of this crop. The Secretariat of Agricultural, Rural and Fisheries Development (SEDARPA), in January 2021 reported that Veracruz is the first national producer of cane and sugar; a figure that represents 40% of national production, as indicated above in Figure 13.

#### 2.3. Primary research

In-depth interviews are a qualitative data collection method that involves direct, one-on-one engagement with individual participants. In-depth interviewing can take place face-to-face, or in some cases over the phone. (Louis, 2022).

In-depth interviews give emphasis to validity. Such interviews explore how close the answers get to the real views of the respondent(s) rather than how accurately the different answers of respondents can be compared. Interviewers can adjust their questions during the interview to change the direction. However, the interviewer must be completely familiar with the subject, potential questions, and plan so that the interview proceeds smoothly and naturally. (Kruse, 2015).

Interviewees can answer the questions asked to them in as much detail as they want. An informal environment encourages the interviewee to be more honest and open so that it is possible to obtain more valid information regarding the attitude, values, and opinion of respondents. (Kruse, 2015).

In November and December 2021, an online interview was conducted with 16 sugarcane producers, who currently live in Lerdo de Tejada, Veracruz, Mexico and with whom I am still in contact since the year 2014 via telephone and social networks through the civil organisation ELIPU.

The draft of the in-depth interview is included in Annex 1. My goal with the in-depth interview was to get to know the most common economic and agricultural problems faced by sugar cane growers, the number of tonnes they harvest, difficulties during the sowing and harvesting period, what are the uses of sugar cane in the communities and why is the crop so important in the region, how many people work in this agricultural activity per hectare, I was interested to know why horses and donkeys are still being used/exploited in the sugar cane juice extraction process, which allows me to look for options to replace the artisanal extraction process with an industrial or mechanised process, so I also asked if they have ever received economic support from the Mexican government in cash or machinery, or what is the economic resource that allows them to continue with the agricultural work and all the expenses involved in planting, harvesting and selling the products and by-products of the sugar cane, and what is the impact of acquiring machinery to replace the use of animals, what type of machinery, what is the use of the machinery and the costs, how they measure the quality level of cane and by-products or what is their opinion of the quality, know the cost in Mexican pesos of growing one hectare of sugar cane and what is the price of sugar cane by-products in order to know if it is viable and profitable, how they face the costs of transport from the field to the storage area, what pest problems or plant diseases are visible, how they consider that the sugar cane sector can improve and be more competitive in Mexico, and if it is worth investing economic resources and technology.

And finally, living in a rural area, with little government support and with sugar cane being the main source of income for the producers, it is necessary to know what opportunities the sugar cane sector has and how I can help them to improve.

Mr. Olivares Hernandez Jose is the sugar cane producer, with whom I keep in contact, he helped me to meet and organise calls with the producers who work with him in the field, besides answering questions they sent me some videos and pictures via whatsapp about the process of cane juice extraction and production of cane by-products.

#### **3. RESULT AND THEIR EVALUATION**

# 3.1. The situation of sugar cane in Veracruz

According to FAO in 2020 the harvested area of sugar cane has a value of 777148 ha. (FAOSTAT, 2020).

In the 2015-2019 period, Veracruz has stood out as the main producing state with 37% and with the largest cultivated area of 35%, followed by Jalisco, San Luis Potosí, Oaxaca and Tamaulipas. (IICA, 2019).

In Mexico, the state of Veracruz is the leading sugar producer with 310,000 harvested hectares and 18 active sugar mills, with a production of 2,620,194 tons, which represents 38% of the national production. (Osoyo, 2020).

Veracruz is the most important entity in the national sugar industry, here are 18 of the 51 mills that are currently operating in the country, which represents 35.3% of production. (Osoyo, 2020).

The main cane producing states are Veracruz, Jalisco, San Luis Potosi, Tabasco, Oaxaca, Michoacan, Tamaulipas, Puebla, Nayarit, Morelos, Chiapas, Sinaloa, Quintana Roo, Colima y Campeche. Below is shown in Figure 14 the number of sugar mills by state:



Figure 14 The number of sugar mills by state, 2018

(Source: CEDRSSA,2018.)

# 3.1.2. Indicators in Veracruz 2019

- Production: 21,788,889 tonnes
- Yield: 74.9 ton/ha
- Area harvested: 290,914 ha
- Sowing area: 303,579 ha (IICA, 2019).

# **3.1.3.** Type of sugar produced in Veracruz

- White: 23,595.55 tons (Minimum sucrose concentration 99.70%).
- Refined: 570,145.8 tons (Minimum sucrose concentration 99.90%).
- Standard: 1,304,794.17 tons (Minimum sucrose concentration 99.40%).
- Mascabado: 159,887.93 tons (Minimum sucrose concentration 96%).

# 3.1.4. Key companies in the food value chain in Veracruz.

- Unión Estatal de Cañeros de Veracruz.
- Unión Local de Productores de Caña.
- Unión Nacional de Productores de Caña de Azúcar de la Confederación Nacional Campesina.
- Organización Cañera de la Cuenca del Papaloapan.

The sugar industry in the country has the capacity to supply domestic demand, in addition to generating surpluses that have historically been exported mainly to the United States. (IICA, 2019).

Main pests affecting the crop are flies, screwworm, rat and locust. They are mainly controlled with agrochemicals and biological control. Diseases present are eye spot, red stripe, mosaic, rust, charcoal, leaf scald and leaf yellowing. Diseases are being combated with susceptible varieties by varieties with resistance. (IICA, 2019).

# 3.1.5 Varieties

The "CP 72-2086" variety is the most widely used in the sugar mill located in the municipality of Lerdo de Tejada, Veracruz with 24.14% of the total cane processed; the Q-96 variety is in second place with 19.86%, the Q-68 variety is in third place with 19.75%. (Pérez, 2014).

The following table shows the distribution of sugar mills in Veracruz, 2019.

Municipality	Location	Sugarmill
La Antigua	José Cardel	El Modelo
Atoyac	General. Miguel Alemán	El Potrero
Coatepec	Mahuixtlán	Mahuixtlán
Córdoba	Córdoba	San Miguelito
Cosamaloapan	Cosamaloapan	San Cristóbal
Cuichapa	Cobos García (San Nicolás)	San Nicolás
Cuichapa	Providencia	Providencia
Cuitláhuac	San José de Abajo	San José de Abajo
Hueyapan de Ocampo	Cuatotolapan Estación	Cuautotolapam
Ixtaczoquitlán	Ixtaczoquitlán	El Carmen
Ixtaczoquitlán	Ejido Cuautlapan	San Pedro
Lerdo de Tejada	Lerdo de Tejada	Panuco San Francisco
Pánuco	Pánuco	Central Progreso
Paso del Macho	Mata del Gallo	Constancia
Tezonapa	Tezonapa	Central Motzorongo
Tezonapa	Motzorongo	Motzorongo
Ursulo Galván	La Gloria	La Gloria
El Higo	El Higo	El Higo
Tres Valles	Tres Valles	Tres Valles

Table 4 Sugar mills in Veracruz, 2019

(Source: National Committee for the Sustainable Development of Sugar Cane, 2019.) Below is the map and the main municipalities of Veracruz Mexico.



Figure 15 Main municipalities in Veracruz, Mexico (Source: SEFIPLAN, 2021)

Most of these sugar mills, are in rural areas in towns with high marginalization rates, which are expressed in low levels of infrastructure, from education, health, housing and the communications and transportation. In fact, since 2000, Veracruz has been classified as an entity with a very high marginalisation index. (SEFIPLAN, 2021)



Figure 16 Lerdo de Tejada, Veracruz, Mexico (Source: SEFIPLAN, 2021)

For centuries, sugarcane has characterized the agrarian landscapes of Veracruz. In the 1930s and 40s, President Lazaro Cárdenas' national-level policies supported projects that had already commenced their development in Veracruz, during a radical period in that state's history. These included the establishment of cooperatives or associations and the application of the national Agrarian Reform program. The decaying of the goals of the cooperative, the transformation of landscapes through forest-clearing and the expansion of sugarcane fields, and the conflicts between ejidatarios and cooperative members are some of the elements that allow us to comprehend the processes of change in that period, in both the territorial and social spheres. (Thiébaut, 2014).

In the 1930s, sugar cane was a consolidated and important crop, grown in various regions of the Republic. It had been developed since colonial times on the coasts and on the Gulf and Pacific slopes, as well as in tropical and subtropical valleys of the interior lands. The system of large sugar cane haciendas of the Porfiriato that concentrated industry and land supply in the same territorial and economic unit continued to predominate, although the Agrarian Reform process progressively ate away at these units, with considerable force since the 1920s in Veracruz and in a large part of the country during Cardenism. (Thiébaut, 2014).

The creation of new sugar cane and sugar poles led to the expansion of sugar cane cultivation and increased sugar production, which led to a crisis of overproduction between 1926 and 1931, during which Mexico had to export at low prices to keep domestic prices stable. In this context, production was concentrated in the larger industries that could produce at low cost, while many medium and small mills were abandoned or remained operating only for the local market. The crisis reinforced the position Veracruz had already acquired as a sugarproducing state. (Thiébaut, 2014).

The locality of El Naranjal, (Figure 16) (former name of Lerdo de Tejada), which was consolidated because of the installation of the sugar mill at the end of the 19th century, grew as the hacienda prospered. The first land distributions in the region, starting in 1923 with the formation of the ejido Angel R. Cabada, were, in addition to the presence of the sugar mill, a strong attraction for people from other parts of the country or from the state itself. From 441 inhabitants living in the village in 1900, the population grew to 1,696 in 1910, 2,108 in 1921 and 3,443 in 1930. (Thiébaut, 2014).

As a sign of its growing importance and demographic boom, the locality became the head of the municipality of Saltabarranca in 1901; and in 1923, it became independent from that municipality, as well as changing from the category of town to that of village. (Thiébaut, 2014).

Apart from the main locality, the colonies of the sugar mill also grew, located within the hacienda, where the field workers lived, close to the sugar cane fields. In 1937, in addition to Ranchería - the workers' colony next to the sugar mill - there was Santa Gertrudis to the north (today part of the town of Lerdo), and the colonies of Santa Teresa, Luisa, Rozas,

Victoria, Carmen and Vista Hermosa between Lerdo and El Mesón. The construction and maintenance of the houses, made of wooden planks and palm or tile roofs, was the responsibility of the mill owners. (Thiébaut, 2014).

Lerdo de Tejada sugar mill was closed in 2012 but was reactivated in 2014. The reactivation gave direct employment to 595 families, in addition to indirect jobs, and to this day its reopening provides economic income to the producers. (Hernández, 2021).

The municipality of Lerdo de Tejada's main economic activity is the sowing of sugar cane, which is why it is home to two sugar mills, one located to the south called San Pedro and the other to the north, San Francisco, where, unfortunately, three deaths have occurred. The location of the sugar mills forced previous administrations to allow the installation of 2 gas stations in the municipal capital. (Sedesol, 2011).

The territory of the municipality of Lerdo de Tejada is in the coastal plain of the Gulf of Mexico, in the Papaloapan region, southeast of the state of Veracruz; at the coordinates 19° 38' north latitude and 95° 31' west longitude, with an average altitude of 10 metres above sea level, although it reaches 120 metres above sea level in the northern part, in the dune area. (Sedesol, 2011).

The municipality of Lerdo de Tejada has two types of climates: warm humid and warm subhumid. The climatological dissection of the municipality obeys to the average amount of precipitation observed in the driest month, since the characteristics of the warm humid climate indicate an annual average temperature higher than 22° C, a historical average of the coldest month of 18° C, as well as an average precipitation of the driest month below 60 mm, affecting all the localities. (Sedesol, 2011).

Precipitation is 2000 mm and he types of vegetation and land use in Lerdo de Tejada, with a surface of 83.6 km2, are: rainfed agriculture (covering 37.2% of the territory, with 31.12 km2), cultivated pasture (occupying 44.85% of the territory, with 37.5 km2), hydrophilic vegetation (with 8.3% of the municipal territory, corresponding to 6.94 km2) and special vegetation of other types (jungle; with 4% of the territory and 3.35 km2). (Sedesol, 2011).

It can be established that the predominant land use in the municipality of Lerdo de Tejada is rainfed agriculture, where the regions covered by hydrophilic vegetation are drastically affected, and the other special types that have been completely lost. (Sedesol, 2011).

The geographical characteristics of Lerdo de Tejada and the properties of the soils favour the development of agricultural activity and in particular the cultivation of sugar cane, promoting the industrial development of the sugar industry in the municipal capital and its surroundings, since the San Francisco and San Pedro sugar mills are located there. San Francisco and San Pedro sugar mills are located there. (Sedesol, 2011).

There are environmental problems, population growth, pressure on water resources, sewage and municipal solid waste generation, land use change and carbon dioxide emissions. (Sedesol, 2011).

The interviewed producers live in Lerdo de Tejada, Veracruz Mexico, this municipality has 26 rural localities and 1 urban locality that in total comprise a surface of 82.4 km2, according to the population census in 2020 in Lerdo de Tejada live 17,727 inhabitants 53% are women and 47% men, the marginalisation rate is 57.5%.. (INEGI, 2020).

In relation to the indigenous population, data from the 2020 population and housing census reveal that in the entire municipal territory, there are only 34 indigenous-speaking inhabitants. (Sedesol, 2011).

The average level of schooling of the population over 15 years of age is 7.9, the most educated population lives in the neighbourhoods near the centre of the municipal capital, the percentage of illiterate population reaches 9.76 %. (Sedesol, 2011).

#### 3.2 The results of the in-depth interview

The results of the primary research from farmers of Lerdo de Tejada are presented below:

**Harvest**: according with the answer from farmers about how many tons of sugarcane do they obtain during the harvest period, 9 of them said around 70 tonnes/hectare. Harvest take

place during January until the first week of May. The maximum amount they have harvested has been 90 tonnes per hectare, it is worth mentioning that the harvest is done by hand with machetes as they have no harvesting machinery. It is necessary to look for a way to finance the purchase of a cane cutting machine to replace the manual cutting work that is currently carried out with machetes. The cane must be loaded without residues and without soil; it is necessary to ensure that it is not left lying in the field, and that it is well stowed and tied on the vehicles so that it does not fall on the road. As a special recommendation, the cane should not remain cut in the field for more than 24 hours, because if it exceeds this limit, it loses weight and its industrial quality deteriorates, and it may be rejected, to the serious detriment of the producers with serious damage to the producers. The harvesting activity is carried out when the stalks stop developing, the leaves wither and fall off and the bark of the plant becomes brittle. The plantation is burned to eliminate weeds that prevent the cane from being cut, as well as possible pests (rats, vipers, gophers) that could cause damage to the cutters.

**Sowing:** Until now sowing is made by hand during March, April, and May. It is easier for farmers to stop planting sugarcane; they are preferring to grow tamarind as it is less tiring work. Hence the importance and urgency of working on innovation.

**Difficulties**: The producers have 2 main difficulties, firstly, from the sowing process to the harvest, they do not have economic resources to pay the workers, sometimes they pay them with money or with sugar cane by-products, the second difficulty is the lack of machinery for the extraction of sugar cane juice, the name of this machinery is "trapiche" only 3 producers out of the 16 interviewed have a trapiche which has deficiencies because the machinery is old but they still use it because they have no other option. Additionally, they use NUTRILIX (Humus de Lombriz Lixiviado) as a organic fertilizer.

**Uses of sugar cane**: In the town of Lerdo de Tejada, Veracruz Mexico sugar cane has 4 main uses: sweetening beverages (coffee), bread production, sweetening sweets and traditional dishes and fodder for sheep and cattle. It is worth mentioning that in other regions of the state of Veracruz sugar cane is useful for ethanol production but the producers interviewed have no experience on this activity.

**Extraction process:** Being a manual or artisanal process where horses and donkeys are used, the producers are working in the process between 10 and 12 hours per day, obtaining between 120 and 150 litres of cane juice in this time. After the juice is boild they obtain 5 tonnes of sugarcane sub-products (piloncillo) per hectare. Bagasse is currently mostly used as boiler as boiler fuel in sugar refineries as well, saving fuel costs.

**Financial support:** 15 producers have never received economic support from the government, 1 of them did receive monetary support for the purchase of a "trapiche" in 2017 through the Ministry of Labour and Social Security.

Monthly costs: There are 4 main costs

1.- Firewood to boil cane juice: \$ 2,400.00, Producers use sugar cane residues to wrap byproducts and some residues are used as fuel to boil the cane, however it is not enough, they need to collect firewood and buy it.

2.- Worker's salary: Each month the total payment is required for approximately 24 workers:\$19,200.00, children and women are also involved in this activity, not only men.

3.- Horses and donkeys: Not all producers have horses and donkeys and it is necessary to rent 8 animals, the monthly payment is \$7680.00.

4.- Transport: From mills to storage at least 4 workers/hectare are required: \$8000.00. no means of transport is used, only human power is used. This cost is paid per week, the salary per men is \$2000.00 but in case of woman is \$1700.00.

5.- Growing stage: In general, the cost of growing one hectare of sugar cane is approximately \$3,600.00 and \$4,000.00 with 10 workers.

**Price-profit**: The price of by-products is different depending on the place where people buy, if people buy in the storage which is close to the field the price per kilogram is \$35.00, in factory \$38.00 and open market \$40.00-\$45.00

However, there is a large amount of production from 137 producers, which lowers the market price and reduces the profit of the producers.

All the producers require support for the purchase of machinery, mainly for the cane juice extraction process, since it is the most difficult process for them due to the time they spend and the implications that exist when using animals, mainly horses, that is, it is a hard process for both parties.

The producers consider that the quality of the cane juice and the by-products obtained from the crop are of high quality because no refining or chemical process is used, it is a 100% natural product for human consumption.

**Financing from government:** During the interview with the producers, I obtained information about how difficult it has been for them to obtain economic resources from the government, producers in general do not have more than secondary education and do not know the procedure to make formal applications to some government agencies, however, in January 2022 I looked for available applications for funding through a written project adapted to the rules of operation necessary to participate. A response was obtained from two organisations via email:

1.-Undersecretary for Social Participation and Craft Promotion, an amount of \$250,000.00 pesos was requested for the purchase of a piloncillo crushing machine.

2.-Eugenio Garza Sada Award: \$150,000.00 pesos was requested for the purchase of a sugar cane squeezer and automatic packing machine for the final product.

At the end of August 2022, the governmental organisations will give an answer about the selected projects, then we will know if the financial resources will be granted for the purchase of the above-mentioned machinery.



Figure 17 Machinery needed: sugar cane squeezer (Source: MT-Maquinaria, 2022)



Figure 18 Automatic packaging machine (Source: Plosa-maquinaria, 2022)

The result of the interview with producers refers to the main technical, environmental and social challenges and impacts such as: training and knowledge about the readiness and availability to use certified seeds in the region and the knowledge of high yielding varieties that are resistant to biotic and abiotic factors, furthermore, it is required to have information about Normativity and regulations, i.e. compliance with minimum standards of production, health and sustainability, on the other hand it is necessary to improve working conditions and perform risk assessment in the field, perform soil evaluation and it is important to combat diseases are more presence in crops and avoid production losses.

#### 4. CONCLUSIONS AND RECOMMENDATIONS

- The cultivation of sugar cane is an activity that generates direct and indirect employment in 15 states of Mexico, and mainly in Veracruz, the main producing state, it is important to carry out actions aimed at improving and implementing machinery that makes the work of producers efficient in the harvest, extraction, and elaboration of sugar substitute products.
- The design of a commercial packaging for crushed piloncillo should be created to introduce it to the market, which will allow a greater supply and demand in the future and the producers will have a better income that will allow them to face the high costs of production, transport, and payment of workers.
- The production and consumption of sugar cane by-products is focused on national consumption, and the option of continuing with an export plan (United States) and the search for new markets should be sought.
- The main barrier to productivity and competitiveness in the sugar sector is the large number of small-scale sugar mills, awareness of local and national consumption should be promoted to benefit Mexican producers and reduce imports of by-products from Nicaragua.
- The objective of the producers interviewed from Lerdo de Tejada, Veracruz, is focused on the production of sugar and by-products, it is advisable to do business for fuel production (Ethanol) since they have never tried it, which will generate income to face the costs of production.
- In case the application for financing for the purchase of machinery is approved, the 6 main companies that buy sugar and by-products in Mexico must be contacted to create a business agreement.
- The features of the cultivation and processing of sugar cane, its social implications and the peculiarities of the sugar market have led to booms and crises throughout the history of our country. These circumstances have necessitated the direct intervention of government policies in an effort to balance and reorganize the sector, as occurs in most countries where this activity is carried out.
- SAGARPA is the entity responsible for mandating and coordinating with the three levels of government. It also coordinates public policies aimed at promoting

profitability, productivity, and the competitiveness of the sugarcane agribusiness, that's why farmers should ask for information to apply for economic support.

- The competitive position of Mexico is low a situation that will worsen if technological improvements that would compensate for this lag and improve performance in sugarcane production are not implemented.
- Sugar mills face serious deficiencies in increasing productivity and competitiveness as there is not complete integration in the value chain of this agricultural industry.
- It is important to continue a thorough investigation of the companies that require sugarcane and by-products as raw material.
- It is therefore suggested that when establishing and applying environmental policies, these should be articulated to the social and economic realities of each community, since in Mexico cane crops can still be burnt before harvesting, which is causing problems between workers and local authorities.
- Not only is machinery deficiency a problem, the period of drought and climate change will impact on production, and if the drought persists, production losses will be higher. Therefore, communication between producers and the National Water Commission (CONAGUA) is suggested to support and manage the design of irrigation policies for the benefit of producers, as the current ones only generate more impact and increase production costs.
- Research on the development of breeding varieties specific to a particular soil type and climatic conditions.
- Continue research related to biotechnology and genetic improvement of sugar cane.
- Continue to seek funding to purchase machinery for mechanised sowing in the future.
- It is recommended to keep in contact with the company Plosa Division Maquinaria located in Guadalajara, Mexico (https://www.plosamaquinaria.com) to follow up on the management of the required machinery.

#### **5. SUMMARY**

The production and industrialisation of sugar cane has been a sector historically forgotten by the Mexican government. In most of the countries producing this crop, analyses have been carried out to examine and reflect on the problems in the production system, but this is not the case in Mexico.

The objective of writing this thesis was to carry out an investigation of the situation and potential development of sugarcane, first looking for general information at the country level, and then analysing the region of Lerdo de Tejada, Veracruz, Mexico to look for alternatives of economic support to improve the quality of life and rural development of producers who live in an area of high marginalization, where there are unacceptable working conditions, child labour, seasonal migrants who receive very poor wages and salaries.

Sugar cane is a crop of great importance for Mexico and is currently facing serious challenges that make it necessary to search for alternatives to make the production system more efficient.

Sugar cane is a staple crop in Mexico, globally it is a competitive crop in terms of production due to geographical location, land suitability and tropical whether of Mexico, but nationally it is a sector that has many areas of opportunity for improvement.

Workers who have been engaged for years in the cultivation of sugar cane are being affected by thermal stress, because they spend a long time exposed to solar radiation at harvest time, so it is urgent to improve working conditions in extraction and cutting of cane mainly and it is necessary to consider this action to address climate change as well.

In the development of the thesis emphasis is placed on the need for innovation, which has and will have an impact on the efficient use of water, knowledge for the use and application of fertilisers (which is not common in Lerdo de Tejada), and the environmental impacts such as drought resistance, frost and flood resistance are visible, so farmers must be prepared to deal with them.

Breaking with traditional technologies will require training and investment in agricultural machinery, specific agricultural machinery for tillage, harvesting and for transporting the cane in pieces to the to the sugar mills to continue with the extraction process.

The sugar mills are ceasing to operate as time goes by because their operation is not profitable and the machinery, they have is approximately 50 years old, which is why the request for financing that was made at the beginning of 2022 must be followed up.

Links should be generated with public institutions in Mexico and international cooperation with organisations that support the agricultural sector. Considering that the process of mechanised sugar cane cutting displaces sugar cane cutters, it is always relevant to consider the economic, social, and environmental implications in a comprehensive and equitable manner, avoiding a higher unemployment rate in the region.

The production costs are higher, and work should be done to diversify the use of sugar cane for purposes other than its traditional use, for example in the pharmaceutical sector, ethanol, and paper production, to stabilise the income of the sector in Lerdo de Tejada, Veracruz. On the other hand, in the development of the thesis, no mention is made of fertiliser costs as currently prices after the pandemic are too high and producers cannot afford them, same farmers are using nutrilix and Aztlan fertilizer which is applicable mainly from stem elongation stage of sugarcane production.

Human factors have a positive or negative impact on the production system and directly or indirectly motivate or ignore the investment of resources and the application of agricultural techniques. For example, land tenure, influence of agricultural policy, market trends, lack of education, granting and release of credit only to large and well-known companies, availability of labour, migration, fluctuation of prices for buying and selling products.

Producers live on the income that society and the environment provide them, which must be accounted for not only in monetary terms, but also in qualitative terms, i.e., the impact on the loss of diversity, soil, water and the deterioration of the atmosphere and the health of the ecosystems and populations that support and surround them must be known. The sugar, like other large-scale monocultures, can lead to significant biodiversity sacrifice, soil erosion and nutrient loss.

Industrial policy is understood as a dynamic process in which the state applies a series of instruments aimed at promoting and strengthening specific activities or economic actors, based on national development priorities or economic agents, based on national development priorities, and within industrial policy there are several instruments, including the strengthening of value chains.

Agricultural policy is understood as state intervention to improve the technical and socioeconomic conditions of agricultural production. However, with new Mexican government administrations, the situation for the sugar sector has worsened, as only large companies benefit from subsidies.

Sugar mills are among the oldest companies in the food production branch, which are close to one hundred years old. Aspects of labour negotiation, elements of productive culture and emphasis on investment, mainly in technology, have complicated the issue of productive diversification, which have sought and practice different ways to transform productive capacity, quality, innovation dynamics, good manufacturing practices and working methods, human factor management and cost minimisation.

It is necessary to know which the big companies are in Veracruz Mexico to form alliances with small producers to consider small-scale production and through these companies continue with the export of by-products to the United States through the NAFTA trade agreement. By updating the Free Trade Agreement with North America, by-products from the cooperatives and producer organisations living in Lerdo de Tejada should be exported, export restrictions are now less restrictive, advantage should be taken of the trade relationship and the geographical proximity.

The geographical location of the sugar mills of Veracruz is a comparative and competitive advantage for foreign trade in relation to other producing states, due to the maritime and air transport port. Promote scientific and technological research on new drought-resistant varieties, the use of biological inputs, as well as the development of the production of sugar cane by-products. Lerdo de Tejada requires the development of a responsible value chain to impact rural, social, and economic development, to promote respect for ecosystems, to eradicate child labour, to know in detail sustainable agriculture and quality and safety assurance, and to promote research in universities.

Since people began to place more value on industrialised products, the essence of the hard work of the producers and the importance of local consumption began to be lost, which is why Veracruz is a tourist region, farmers should take advantage of this to promote local consumption of sugar cane by-products. It is urgent to develop a comprehensive strategy to raise productivity and reach a potential in the sugar cane agro-industry that is competitive in order to maintain and improve its position in the local, regional and national market and at the same time be profitable in order to attract investment to the countryside and sustainable in order to raise production and productivity, taking care of the environment and natural resources, with a fair benefit for producers and workers involved in this economic activity and thus reduce dependence on external markets.

#### 6. **BIBLIOGRAPHY**

Aguilar, R., 2012. *The Mexican Sugarcane Industry: Overview, constraints, current status and long term trends,* Mexico: Universidad Veracruzana.

Aguirre, B., 2021. World sugar production. *Forbes Mexico*, p. 02.

Arroyo, J. U., 2020. Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food.. [Online]

Available at: <u>http://dof.gob.mx/nota\_detalle\_popup.php?codigo=768892</u> [Accessed 16 June 2021].

Baliño, S., 2019. *Global Market Report: Sugar,* Canada: International Institute for sustainable Development.

Bank, W., 2019. Mexico Rural Population 1960-2021, Mexico: Macrotrends.

Bank, W., 2022. Mexico, agricultural land, Washington: Trading economics.

Burton, T., 2021. The geography of Mexico's sugarcane industry, Mexico: Geo Mexico.

Carrillo, T. C., 2021. *Analysis of the economic, technological and market policy status of the sweetener sector in Mexico*, Mexico city: Department of Basic Industries, Ministry of Economy.

Cuello, C. M., 2018. Land management in Mexican sugarcane crop fields, Mexico: Science direct.

Espinoza, I. M., 2019. *Sustainable development law for sugarcane,* Mexico city: Secretary of goverment.

Espinoza, M., 2005. *The sustainable development law of sugarcane*. Mexico city: Secretary of government.

FAOSTAT, 2020. Sugarcane area harvested, FAO Departments and Offices: FAO.

Hernández, N. C., 2021. *Reactivan ingenio San Francisco en Lerdo de Tejada,* Veracruz Mexico: Grupo Pazos.

Herrera, H. E. S., 2017. *The Mexican sugarcane production system: History, current status and new trends,* Mexico: Research Gate.

IICA, 2019. *Infografia agenda veracruz, principales productores de caña de azucar 2018,* Mexico: INNOVAGRO.

INEGI, 2020. Lerdo de Tejada, Veracruz: SEFIPLAN; Subsecretaría de Planeación; DGPE..

Kingdom, E. o. M. i. U., 2021. The Economy, Mexico: Embassy of Mexico in United Kingdom.

Kruse, B., 2015. *In-depth Interviews – Features, Uses and Transcription,* Tulsa: Mos Transcription company.

Louis, S., 2022. *In-Depth Interviews: Data Collection Advantages and Disadvantages,* Waynesville: Communications for research.

Lundy, C., 2021. Veracruz, San Diego: Mexico insurance services.

Maastricht, R. P., 2021. Research project Maastricht. In: J. Wijckmans, ed. *Build a brighter future.* Netherlands: Maastricht University, pp. 4-5.

Osoyo, A., 2020. Sugar Annual, United States: United States Department of Agriculture.

Osoyo, A., 2020. Sugar Annual, United States department of Agriculture, Mexico city: USDA.

Pérez, M. M. E., 2014. CRECIMIENTO INICIAL DE CINCO VARIEDADES DECAÑA DE AZÚCAR, Quintana Roo, México: SEP.

Péter, P., 2013. *Integrated Crop Production III,* Debrecen: University of Debrecen, Service Sciences Methodology Centre.

Río, E. d., 2013. Agricultural policy of Mexico. In: *Objective Definition of Economics*. Mexico: Agrobusiness, p. 03.

Rivera, N. A., 2018. *Constraints for Mexican sugar industry and biorefineries competiveness,* Mexico: Science direct.

Rivera, N. A., 2018. Land management in Mexican sugarcane crop fields, Xalapa Veracruz: Science Direct.

Rodríguez, D. A., 2020. The Mexican Sugarcane Industry: Overview, Constraints, Current Status and Long-Term Trends, Mexico: Research Gate.

Rodríguez, H. R. H., 2020. Secretary of Goverment.

Rutledge, K., 2011. Rural area, Washington, D.C: National Geographic Society.

Sedesol, 2011. *Atlas de Riesgos Naturales del Municipio de Lerdo de Tejada, Veracruz,* Municipio de Lerdo de Tejada, Veracruz: s.n.

Service, D. o. A. F. A., 2021. *Sugar: World Markets and Trade,* United States: Global Market Analysis.

Sinha, S., 2021. The geography of Mexico's sugarcane industry, Canada: Geo Mexico.

Stockbridge, M., 2015. Rural Development. In: A. Dorward, ed. *Centre for Development, Environment and Policy*. London(London): SOAS University of London, p. 92.

Thiébaut, V., 2014. *Sugarcane Landscapes in Veracruz in the Decades of 1930 and 1940.*, Veracruz, Mexico: s.n.

Vargas, L. A. O., 2018. Land management in Mexican sugarcane crop fields. In: *Sugarcane production*. Mexico: Use land policy, p. 14.

Voora, V., 2020. *Global Market Report: Sugar,* Canada: International Institute for Sustainable Development.

# LIST OF TABLES

Table 1 Market regulation in Mexico	23
Table 2 Support programs	24
Table 3 General data of Mexico	28
Table 4 Sugar mills in Veracruz, 2019	36

# LIST OF FIGURES

Figure 1 Global sugarcane production in 2019	11
Figure 2 Global harvested area in 2019	12
Figure 3 Harvested area between 2010 and 2020	12
Figure 4 Annual yield of sugarcane between 2010 and 2020	13
Figure 5 Production quantity between 2010 and 2020	13
Figure 6 Land suitability for rainfed sugarcane crop in Mexico, 2018	15
Figure 7 Agricultural land in Mexico, 2018	
Figure 8 Export in million metric tons	
Figure 9 Consumption in metric tonnes by the major companies	18
Figure 10 Sugarcane in America	
Figure 11 Rural population in Mexico in 2021	26
Figure 12 Urban population in Mexico, millions of people	
Figure 13 Location of Veracruz, Mexico	30
Figure 14 The number of sugar mills by state, 2018	34
Figure 15 Main municipalities in Veracruz, Mexico	36
Figure 16 Lerdo de Tejada, Veracruz, Mexico	37
Figure 17 Machinery needed: sugar cane squeezer	
Figure 18 Automatic packaging machine	44

# ANNEX 1

#### **Questions of interview to 16 farmers**

- What are the different uses of sugar cane?
- How many tons of sugarcane do you obtain in the harvest period?
- What are the problems that you have identified in the cultivation of sugar cane?
- What difficulties have you had during the sugarcane planting and harvesting period?
- How many people work in this agricultural activity per hectare?
- Being a manual or artisan extraction process with the help of two horses, how many hours do the people responsible for the extraction process work per day and how many books of cane juice are obtained?
- Have you ever received financial support or machinery with help from the government?
- Do you think it is important to buy machinery to make the sugar cane extraction process efficient?
- What machinery do you need?
- What is your opinion on the quality of the cane that you produce?
- What are the costs that you have during the sugarcane production process?
- What is the cost of growing one hectare of sugar cane?
- What is the price of sugarcane by-products?
- What opportunities do you think the sugarcane sector has?
- What is the cost of transportation from the field to the sugar cane storage place?
- What pest or disease problems have you found in sugar cane?
- How do you think the sugarcane sector can improve in Mexico?
- Do you consider that the sugar cane sector is a profitable activity in which it is worth investing economic resources and technology?

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# **Declaration of Consultations with Supervisor**

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Name of Thesis Supervisor: Dr. Szűcs, Antónia

First personal consultation Date and time: 19.02.2021

Topic discussed: research topic, objectives, literature review

Signature of Supervisor:

Second personal consultation

Date and time: 20.09.2021

Topic discussed: primary and secondary research methods, evaluation of results

..

Signature of Supervisor: 5

Third personal consultation Date and time: 07.02.2022 Topic discussed: conclusions, finalisation of the thesis

Signature of Supervisor:

#### STATEMENT ON CONSULTATION PRACTICES

As a supervisor of CRUZ MENDOZA GRACIELA, (DQRFKU), I here declare that the final thesis has been reviewed by me, the student was informed about the requirements of literary sources management and its legal and ethical rules.

I recommend the final thesis to be defended in a final exam.

The document contains state secrets or professional secrets: yes no

Place and date: Gyöngyös, 27 October 2022.

Mcha Gili-Internal supervisor

Dr Gábor Koncz